Faculty of Engineering & Technology
Electrical & Computer Engineering Department

ENCS3340 Artificial Intelligence
ENCS3340

Homework #2

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Section: 4

Q1: Use a truth table to prove modus ponens is sound for propositional logic and to prove that ¬P∨Q is equivalent to P → Q

P	Q	~P	P → Q	~P ∨ Q
T	T	F	T	T
T	F	F	F	F
F	T	T	T	T
F	F	T	T	T

Q2: Represent the following sentences in first-order logic:

a. All swans are white.

∀x, Swan (x) → white (x)

b. There is a black swan.

∃x, Swan (x) ∧ Black (x)

c. All bowlers drink soda.

∀x, Bowler (x) → Drinks (x, Soda)

d. Some dogs have fleas.

∃x, Dog(x) ∧ Has (x, Fleas)

e. There is somebody who loves everyone.

∃x ∀y, Loves (x, y)

f. Everybody is loved by someone.

∀x ∃y, Lovedby (x, y)

g. There is a barber in Ramallah who shaves all men in Ramallah who do not shave themselves.

∃x ∀y, Barber(x) ∧ Lives (x, Ramallah) → Shaves (x, y) ∧ Lives (y, Ramallah) ∧ ~Shaves (y, y)

h. Politicians can fool some of the people all of the time, and all of the people some of the time, but they can't fool all of the people all of the time

∀x, Politician(x) → [(∃y, ∀t Person(y) ∧ Time(t) → CanFool (x, y, t))) ∧ (∀y, ∃t Person(y) → Time(t) ∧ CanFool (x, y, t)) ∧ (∀y ∀t, Time(t) ∧ Person(y) → ~CanFool (x, y, t))]

Q3: Find the Most General Unifier (MGU), if one exists for the pairs:

1. f (g (x, y), c) and f (g (f (d, x), z), c)

   S1= {f (d, x)/x} failure because x is in f (d, x)

   NO MGU

2. h (c, d, g (x, y)) and h (z, d, g (g (a, y), z))

   S= {}

   S={c/z}

   S= {c/z, g (a, y)/x}

   S = {c/z, g (a, y)/x, c/y} so S2= {c/z, g (a, c)/x, c/y}

   MGU➔ S= {c/z, g (a, c)/x, c/y}

3. P(f(a), g(x)) and P (y, y)

   S= {}

   S={f(a)/y)}

   S={f(a)/y, f(a)/g(x)}

   MGU➔ S={f(a)/y, f(a)/g(x)}

4. P (a, x, h(g(z))) and P (z, h(y), h(y))

   S= {}

   S={a/z}

   S= {a/z, h(y)/x)}

   S= {a/z, h(y)/x, g(a)/y}

   S2= {a/z, h(g(a))/x, g(a)/y)}

   MGU➔ S2= {a/z, h(g(a))/x, g(a)/y)}

5. P (x, x) and P (y, f(y))

   S={f(y)/x}

   S={f(y)/y} failure because y is in f(y)

   NO MGU

6. P (a, f (x, a)) and P (a, f(g(y), y))

   S= {}

   S={g(y)/x}

   S={g(a)/x, a/y}

   MGU➔ S={g(a)/x, a/y}

Q4: Assume KB consists of the following rules:

- R1: Soda(x) ^ Chips(y) → Cheaper (x, y)
- R2: Chips(x) ^ Cereals(y) → Cheaper (x, y)
- R3: Cheaper (x, y) ^ Cheaper (y, z) → Cheaper (x, z)

And the facts:

- F1: Soda (Sprite)
- F2: Chips (Ruffles)
- F3: Cereals (Cheerios)
- F4: Cereals (MiniWheats)

a. Assume that all facts F1-F4 are known at the beginning of the inference process. Illustrate the process of forward chaining by listing **all** newly inferred facts. Assume that both rules and facts are matched and tried in the order of their appearance.

→ From F1, F2: Soda (Sprite) ∧ Chips (Ruffles) ➔ F5

From R5, R1: Soda (Sprite) ∧ Chips (Ruffles) → Cheaper (Sprite, Ruffles) ➔ F6

→ From F2, F3: Chips (Ruffles) ∧ Cereals (Cheerio's) ➔ F7

From F7, R2: Chips (Ruffles) ∧ Cereals (Cheerio's) → Cheaper (Ruffles, Cheerio's) ➔ F8

→ From F6, F8 and R3: Cheaper (Sprite, Ruffles) ∧ Cheaper (Ruffles, Cheerio's) → Cheaper (Sprite, cheerio's)

→ From F6, F8 and R3: Cheaper (Sprite, Ruffles) ∧ Cheaper (Ruffles, MiniWheats) → Cheaper (Sprite, MiniWheat)

b. Show how to prove Cheaper (Sprite, Cheerios) using backward chaining and the KB given in part a. Draw the graph for the problem, assuming rules and facts are tried and matched in the order given.

let Cheaper (Sprite, cheerio's) $\Longrightarrow$ K1

From K1 and R3:

Cheaper (Sprite, Ruffles) $\Longrightarrow$ K2

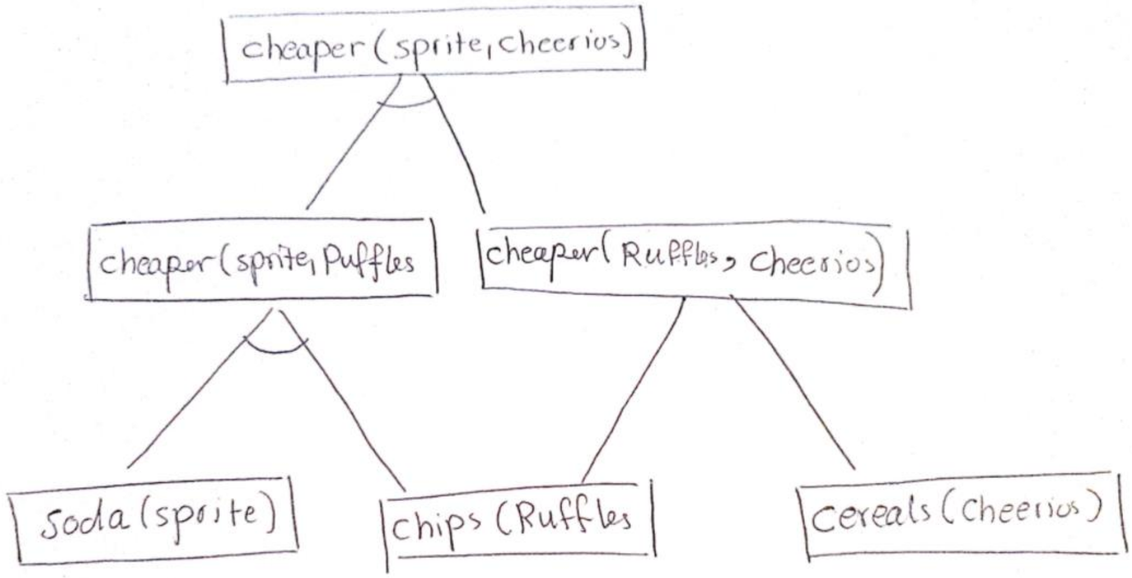
Cheaper (Ruffles, cheerio's) $\Longrightarrow$ K3

From K2 and R1:

Soda (Sprite), Chips (Ruffels)

From 3 and R2:

Chips (Ruffels), Cereals (Cheerios)



Q5: Prove each of the Goals: Grandfather (Ali, Hasan) and Grandparent (Ali, Mariam) (each separately) by refutation resolution from the following clause set. Is the clause set definite?

1- Grandparent (x, y) ∨ ¬Parent (x, z) ∨ ¬ Parent (z, y).

2- Parent (x, y) ∨ ¬Father (x, y).

3- Parent (x, y) ∨ ¬Mother (x, y).

4- Father (Ali, Muna).

5- Mother (Muna, Hasan).

6- Mother (Muna, Mariam).

7- Grandfather (x, z) ∨ ¬Grandparent (x, z) ∨ ¬ Male (X)

8- Male (Ali)

ASSUME: A1- ¬ Grandfather (Ali, Hasan)

A2- ¬ Grandparent (Ali, Mariam)

- **Grandparent (Ali, Mariam)**

  4+2: **GIVES:** Parent (Ali, Muna) … (9)

  3+6: **GIVES:** Parent (Muna, Mariam) … (10)

  9,10: **GIVES:** Parent (Muna, Mariam) ∧ Parent (Ali, Muna) ……. (11)

  11,1: **GIVES:** Grandparent (Ali, Mariam) … (12)

  12+A1: {} Empty Clause!

- **Grandparent (Ali, Hasan)**

  2+4: **GIVES:** parent (Ali, Muna) ……. (9)

  3+5: **GIVES:** parent (Muna, Hasan) ………… (10)

  1+9+10: **GIVES:** Grandparent (Ali, Hasan) …… (11)

  8+7: **GIVES:** Grandfather (Ali, z) ∨ ¬Grandparent (Ali, z) …… (12)

  11+12: **GIVES:** Garndfather (Ali, Hassan) ……. (13)

  13+A2: {} Empty Clause!